# INTERNATIONAL INSTITUTE

FOR

## PRESERVING AND PERFECTING

# Weights and Measures.

ACTUAL MEASURES OF THE GREAT PYRAMID OF EGYPT, IN TERMS OF THE BRITISH INCH: DISCLOSING, BY ITS MEANS, THE ARCHITECTURAL SYSTEM EMPLOYED IN THE CONSTRUCTION, TO ACCOMPANY THE SECTIONAL PLAN PREPARED BY MR. CHARLES LATIMER.

CLEVELAND, OHIO:
PUBLISHED BY THE SOCIETY.
1881.

Entered according to the Act of Congress, in the year of our Lord 1880, by
J. RALSTON SKINNER,
in the office of the Librarian of Congress, at Washington, D. C.

# PREFACE.

The following specifications of the *architectural* measures of the Great Pyramid of Egypt, have been especially prepared for the Auxiliary Society of this Institute. The object is, that the detail of measures may accompany the sectional plan of the pyramid, prepared for the Society by Mr. Charles Latimer.

The plan and its measures afford, in the opinion of the author, because of the rigid exactness of the work, convincing evidence that the British inch, viz., the standard taken by Capt. Kater (of the Royal Commission in England), for Scotland, was the *standard unit* of measure by which, some thousands of years ago, the pyramid was constructed, in whole and in part.

Beyond this, it will be seen, that the British inch is, (1), founded on the *numerical expression* of the geometrical relation of circumference to diameter of a circle; (2), that it is the *base* on which were constructed the ancient cubit values; (3), that the cubit values in the pyramid run correlatively and and co-ordinately, with the British measures, in terms of inches, feet, yards, and miles; and (4), that the cubit values when reduced to British feet and inches, in the measures of the pyramid, exhibit measures of *time* and *astronomy*.

If these things are so, then the whole world possesses no unit of measure so precious as this British inch. It has a

history of some five thousand years, at least. It has preserved its own integrity during that period. It is founded on an eternal gometrical truth, and applies as well to interpret the handiwork of God in the heavens, as the works of man on the earth.

J. RALSTON SKINNER.

*Toledo, (Easter)*, 1880.

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## OIHO AUXILIARY SOCIETY, CLEVELAND.

### ACTUAL MEASURES OF THE GREAT PYRAMID OF EGYPT, DISCLOSING THE ARCHITECTURAL SYSTEM EMPLOYED.

It was discovered by Rev. John Taylor, that the *height* of the pyramid of Jizeh, or Cheops, bore the relation to *twice the base side*, of *diameter to circumference of a circle*. This relation is *typical* of its interior construction.

Take the numerical form 20612 : 6561. This is agreeably to the late John A. Parker, of the City of New York, the true integral relation of circumference to diameter of a circle. What is called the *pi* value of this expression is 3.14159426+. The Legendre, or established value, is 3.14159265+. The

difference in all but extraordinary exceptions, is quite inappreciable—the value used in ordinary engineering is 3.1416.

§ 1. (*a*) Take this form, 20612 : 6561, as $20^{612} : 6^{561}$, and consider it as *British inches;* then this $20^{612}$ B. inches is the ancient Egyptian *Cubit* value, one of the so-called royal cubits. From measurements of this pyramid by Prof. Greaves, of Oxford, England, Sir Isaac Newton restored the value of this ancient cubit, which, to specialize it, is now called the *Turin cubit*, as 20.604 B. *inches*, or 1.717 B. *feet*. From measures of the catacombs of Osimandya, Egypt, by the French *savans*, under Napoleon, this cubit was restored in terms of the French meter, as .523524, which gives, by reduction to B. *inches*, $20.^{61156}$. This last value, *plus* .00044 of the inch, equals $20^{612}$, or the above given value of circumference. We take it, then, that the true restoration of this cubit is $20.^{612}$ British *inches;* and that it had its origin from the geometrical source of 20612 : 6561, or of circumference of a circle whose diameter is 6561.

(*b*) Take the form, or proportion—

$20^{612} : 6.^{561} : : 64.^{8} : 20.^{6264700174+}$ as in British *inches*. It is seen that the fourth term is exceedingly near in value to the *first* term; yet is, indeed, of a very significant difference. (1) While the first term is a *circumference* or curved value, the fourth term is a *diameter*, or straight line, value. (2) This fourth term is diameter to an integral circumference value, viz., $64^{8}$.

Now, this fourth term, as B. *inches*, is the so-called *Nilometer cubit* value, or the other of the royal cubits. The restoration of this cubit value, by Mr. Wilkinson, was found to be $20.^{625}$ B. *inches*, showing a difference from the above of .0015 of an inch.



Thus we see that these two royal cubits were geometrically related to each other, and referred themselves to the above numerical relation of circumference to diameter of a circle.

(*c*) Take $6^{561}$ out of the above formula, as B. *inches*—multiply it by $\frac{16}{9}$, and the result will be $11.^{664}$ B. inches. This result gives the restored value of the ancient Roman *foot*. An abundance of authorities could be given for this.

§ 2. The *analytical unit* of measure, so-called, in geometry, is obtained by the formula $\frac{180}{pi}$.

This analytical unit is where the length of a curved line of a circle is the same, numerically with the lengths of the two radii embracing that curve. By the above form of Mr. Parker, in the circle of 360°—(1), the radii, containing the curve; (2), the curve itself; and (3), the angle measuring the curve; all are numerically of the same value, thus—

Value of radius, say in feet.....57.295750048+
Value of curve.....57.295750048+
Value of angle, in degrees.....57°.295750048+

Here it is seen that *feet*, or any other unit of measure, can be read as *degrees*. The two readings are convertible. Now, this *analytical unit* is directly obtainable from the above proportion; for divide 64800 : 20626.4700174+ by 360, and there results 180 : 57.2957500.48+, or circumference to diameter. If 57.295+ is taken as *radius*, then 180 must be multiplied by 2, making 360 for its circumference.

(*a*) This is given, because, while the type of the structure of the pyramid is circumference to diameter, the subordinate

from which the type is taken is this veritable analytical unit of measure.

### THE DESCENDING PASSAGE-WAY.

§ 3. (*a*) The measure of the floor line of this passage is given by Col. Howard Vyse, as "about 4126. inches."

The length of this line seems to be a key to the interior construction in many measures and, in fact, of the proportions of the entire mass.

Multiply 100 Nilometer cubits by 2, or

$$2062.\overline{647001}74 \times 2 = 4125.29400348+ \textit{inches}.$$

or, $343.774500291+ \textit{feet}.$

or, 200 Niliometer cubits. This is the length of the floor-line of this passage-way.

(*b*) 343.7745+feet, is diameter to a circumference of 1080 feet. Now, 1080 is the number limiting the Hebrew measures of *time*—1080 scrupules is equal to one *minute*. They had a calendar form made of three values, viz., the luni-solar year of 355 days, the calendar year of 360 days, and the vague solar year of 365 days; and 355 + 360 + 365 equals 1080.

(*c*) $206264.\overline{7001}+$ is radius of a circle used at the present day in the formula for finding the sun's parallax and distance (See Godfray's Astronomy).

(*d*) 3437.74500271 + as *minutes*, is the number of minutes in the radius of the *analytical unit* of measure, or of the circle of 360°, Therefore, $206264.\overline{7001}+$ is that radius in *seconds*. For, 57°.295750048+ × 60 equals 3437′.74500271+ *minutes*, etc. Thus it is seen that these measures are *astronomical;* and co-ordinate measures of *space* and *time*.

(*e*) Herschel says a ray of light from *a* Draconis (the Pole Star, at the time of building the pyramid), at its lower culmination, looked down the passage-way. As the earth in passing around its orbit did not displace this star, this ray might be taken for the immovable axle around which the heavens actually turned; and the lower end of the passage might be taken as the center of the earth. Then the length of the passage-way, as *feet*, might numerically be taken as the *radius*, In *minutes*, of the terrestrial circle of 360°, and likewise as the radius as a celestial circle of 360° sweeping so as to cut and include the North Star. This shows that our astronomical modes have descended from a date at least as remote as the building of this pyramid.



### THE LOCATION OF THIS PASSAGE-WAY.

§ 4. This passage must be located *exactly* right, relatively (1), to the exterior slope of the mass; (2), to the ground-level of the foundation; and (3) to the vertical axial line of the pyramid—otherwise, the locations and measures of the interior works *must* fail. So also with regard to the *height* of the passage, perpendicular to its incline.

(*a*) The passage enters on the *north* slope of the pyramid, at a considerable distance above the *pavement*. The *pavement* is *one* Turin cubit thick, and is included in the mass of the pyramid. Vyse gives this thickness, measured here and there, as 21 inches. One Turin cubit is $20\frac{612}{}$ B. inches. It was a matter of great difficulty to solve the problem of the *vertical* elevation of the intersection of the floor line of the passage-way with the slope line of the mass. Col. Vyse's angle of the passage was 26° 41′, considerably too great. His elements of measure, calculated by one of Piazzi Smith's angles, viz., 26° 28′ 7″, which is exceedingly accurate, gives this vertical height above the ground level as 53.1975+ feet.

Now, the vertical height of this intersection above the ground level is precisely 20.612 inches × 31, or 31 Turin cubits. This includes the pavement thickness of 20.612 inches, one T. cubit. Above the pavement, then, this line is just 30 T. cubits, and this is precisely 51.53 feet.

A base line run horizontally from the foot of this 30 cubit line, so as to intersect the slope of the pyramid, will be 40.4715881+ feet; and this will bear the proportion to 51.53 as ¼ of a circumference to a full diameter—and we will have the proportion

$$40.47+ : 5.53 : : 51.53 : 65.61.$$

Now, Mr. Parker says that a square of 81 to the side gives an *area* of 6561; and that the *area* of the circle inscribed in this square, will be 5153. But changing from *area* to *linear* measure, then, he says, a circle having 6561 for its diameter, will have a circumference of 5153 × 4 equals 20612.

Thus, one standing on this pavement, and ascending to the mouth of this passage-way, has, in fact, under his very nose, the *geometrical modulus* from whence the proportions and measures of the pyramid.

(*b*) A *vertical* line, raised from the very foot of the floor-line of this descending passage-way, and extended to touch the horizontal ground level or base line of the pyramid, will be exactly 100 British feet, or 1200 inches.

The half base side of the pyramid, in feet, is diameter to a circumference of just 1200 feet. Here, in this 1200 inches, we have in a scale of inches for feet, the same number, and may serve as a check.

(*c*) Having thus located this floor line of the descending passage-way, we can take its angle of elevation, to compare it



with the observations of Prof. Smyth, taken with so much care. This angle is found to be 26° 28′ 24″10. Of the various angles taken by Prof. Smyth, all taken with the same care, and having the same probability of being correct, as he says, we will take the mean of 10, taken with the circular clinometer. The mean is 26′ 28′ 16″, showing on comparison, a difference of only 8″; an amount exceedingly difficult to read on an instrument.

(*d*) It now remains to obtain the *height* of this passage-way *perpendicular to its incline*. This must be obtained with absolute accuracy; otherwise, no right measures can be had as to the upper interior works resting on this passage-way. Piazzi Smyth's most approved measure of this height is 47.24 inches. The architectural measure is 47.2519656+ inches. Draw in a roof line of this passage-way, at this height; make this line parallel to, and of equal length with, the floor line, intersecting the slope line of the pyramid and thence down to the foot of the passage. From the extreme lower end of this roof line drop a perpendicular, say *a b*, upon the floor line of the horizontal passage-way. The length of this line, *a b*, is the key to the height of the passage; and necessarily also fastens the location of the passage-way as to elevation or angle.

The length of this line, *a b*, is 3.16227666 + feet, or 37.94733192+ inches. The interpretation of this line is very remarkable. Form of circumference to diameter is 20612 : 6561, as said. Circumference to a diameter of 1 foot is 3.14159436+ feet. Diamater to a circumference of 10 feet is 3.18309722+ feet. The *mean proportional* between these values is (as stated) the value of *a b*, or 3.16227766+ feet.

Now, this last value is the *square root* of 10. In inches, or 37.94733192+ inches, it is the square root of 1440 inches. This half base side of the pyramid is diameter to a circumference of 14400 inches—thus the relation becomes manifest. This half base side equals $\frac{200}{18}$ of the length of the King's Chamber. This half base side is connected in relation to the descending passage-way and to the King's Chamber, etc. Hence this 1440, which is $12^2$ multiplied by 10, seems connected all through the structure. So also, 1440 as *minutes*, equals one day of 24 hours. Hence co-ordination with measures of *time*.

(*e*) The length of the horizontal line (or the floor line of the passage-way to the *subterranean chamber*), from the foot of the floor line of the descending passage-way to the vertical axial line of the pyramid itself, is 32.4237769849+ feet, or 389.0853+ inches. Howard Vyse gives the perpendicular height of this horizontal passage, as 36 inches, or 3 feet or 1 yard. He gives the length of the roof line of the horizontal passage to the subterranean chamber, as 324 inches, or 27 feet, or 9 yards.

### THE BASE SIDE AND HEIGHT OF THE PYRAMID.

§ 5. The length of the descending passage-way is 200 Nilometer cubits. Add $\frac{1}{9}$ of this to itself, and then in $222\frac{2}{9}$ cubits we have the length of the half base side of the pyramid. 2062.64700174+ inches × 2 gives the length of this passage-way. To 2062.64700174+ add its $\frac{1}{9}$th, or 229.18300019+, and there results 2291.8300019+. Multiply by 2, and we have 4583.660003880+ inches, or 381.971666990+ feet. This is the half base side of the structure; and the entire base side is 763.94333398+ feet, or 9167.320007760+ inches.



The French measured this as 9163.44 inches.
Col. Vyse measured it as 9168. "

(*a*) This line, in the first place, is seen to be directly related to the length of the descending passage-way.

(*b*) In this measure of B. feet, this 763+ feet is diameter to a circumference of precisely 2400 feet; as inches of 28800 inches.

(*c*) The $\frac{1}{9}$ of $\frac{1}{2}$ the descending passage-way, in inches, or 229.183+ inches, was thus taken as an exhibit, because this length of 229.183+ inches is the height of the King's Chamber.

The height of the pyramid itself, were it not truncated, is diameter to a circumference of twice this base side; consequently, it must be 486.$\overline{341+}$ feet. This condition demands that the angel formed by the slope line with the ground level must be 51° 51′ 14″5. However, Vyse measured the angle of a casing-stone, *in situ*, and found it 51° 50′ to 51° 52′, which almost conclusively shows the true measure.

From what has been said, viz., that the base length is diameter to a circumference of 2400 feet, it becomes obvious that an equivalent structure can be made on a base of 2400 feet. Take 24 inches, or 24 feet, as a base side. Construct on this a relatively proportional pyramid, in all its details. Then, taking the Parker *modulus*, if these measures are converted from circumference to diameter values, the exact real measures of the pyramid will result numerically.

Note—If the pyramid be constructed from the form 20612 : 6561, instead of the Nilometer measure, then its $\frac{1}{2}$ base side would be 381.7037037+ feet, to a height of 243 feet. Now, the real pyramid *is* truncated, and the little pyramid so cut

off approximates (at the line of finish, or the platform) very closely to 31.808+ feet for base, and 20.25 feet for height. As inches, these values are respectively 381.7037+, and 243.

LENGTH OF THAT PART OF THE VERTICAL AXIAL LINE OF THE PYRAMID BETWEEN THE GROUND LEVEL, OR FOUNDATION, AND THE INTERSECTION OF THE FLOOR LINE OF THE GRAND GALLERY.

§ 6. This is one of the salient governing lines, because it is the vertical axial line of the entire pyramid. That the Grand Gallery floor line terminates with this intersection, shows that the architect worked up to this vertical axial line as a governing one. It would show this more conclusively did the height of this vertical line to this intersection, show (1) some comprehensive measure, and (2) co-ordination with other measures, in identical kind, and in likeness of use.

(*a*) This line is 8° Nilometer cubits. Multiply 20.6264700-174+ by 80 and we have 1650.11760139+ inches, or 80 N. cubits. The peculiarity of the line is that it, in inches, is diameter to a circumference of exactly 5184 inches. Taken as square inches, this is the number of square inches in 4 square yards. But taken as a time measure, this is the characteristic value of a solar day in *thirds*, because 5184000′′′ equals one solar day. So 5184 is 72×72, or the square of 72; and 72 is circumference to a diameter of 22.9183+ or the $\frac{10}{9}$ths part of a Nilometer cubit. 80 cubits×72,$^5$equals the length of the descending passage-way. 80 cubits divided by 4 equals 20 cubits, or the length of the King's Chamber, etc. The fact is, that this measure is wonderfully comprehensive, and, as if to accord with this fact, perhaps the most remarkable feature



about it is to be related—it is the terminal or closing of the Hebrew scale of long measures, in the technical term of *The Measuring Line:* that is, "80 cubits make 1 measuring line" (Bagster's Polyglot Bible).

In actual pyramid work the value of this line is confirmed by such a number of architectural conditions, harmonies, and so on, that it would take up too much space to enumerate them.

FLOOR LINE OF GRAND GALLERY.

§ 7. Let us work back from this intersection—and *first* in order comes the floor line of the Grand Gallery. Piazzi Smyth gives this line—"Full length, east side, 1882.6 inches; full length, west side, 1883 inches." The length of this line is $91.\frac{33}{100}$ Turin cubits.

20.612 (Turin cubit, in inches) × $91.\frac{33}{}$ = 1882.49396 inches. This differs from Mr. Smyth's measure by $\frac{1}{10}$ of an inch in this great length of actual measure by him.

With respect to the vertical axial line, the floor line of the Grand Gallery had to be placed agreeably to Prof. Smyth's angles. He took means of sets of trials. One 26° 17′ 4″, one 26° 17′ 3″, and one 26° 17′ 53″.

The author found a mode, by these cubic values, of finding the horizontal distance from the foot of the Grand Gallery to the Queen's Chamber. By this mode (Crown Jewels, page 55), this distance was found to be 1519.3507+ inches. Piazzi Smyth's measure of this line was 1519.4, showing a difference of .04 of an inch. Then, moreover, it appeared that the typical width of the Queen's Chamber was taken at 206.12 inches, or 10 Turin cubits (typical width of King's Chamber 10 Nilometer cubits). Then, a very curious fact disclosed

itself, viz., that by these measures, *the relation of the Queen's Chamber to the vertical axial line*, worked as a mode of placing all the lines, and of confirming their measures. The author found that a portion of the *width* of the Queen's Chamber, was *cut off to the west of the vertical axial line*, and that the portion thus cut off measured 3.14159436+ *feet*, or circumference in feet (under the Parker mode) to just *one linear foot*, British measure, for its diameter—that is, just 12 B. inches. This result was literally amazing. And this being done, changed the angle of location of the floor line of the Grand Gallery *but a very few seconds*. The author then found that this feature served, also, as a mode of determining the height and true width of the Queen's Chamber; confirming, thereby, its typical width of 10 T. cubits or 206.12 inches. The vertical height from this horizontal line to the intersection of the floor line of the Grand Gallery, with the vertical axial line, was found to be 69.48255243+ feet.

It will be observed that the space of the length of the floor line of the first ascending passage is now left undetermined; and it will depend upon the measure of its closing, in comparison with Mr. Smyth's most exquisitely accurate results, whether all the work hereinbefore stated has been accurately and *architecturally* correct.

### DISTANCE FROM ARCHITECTURAL FOOT OF ROOF LINE OF THE DESCENDING PASSAGE-WAY, UPWARD ON ITS INCLINE, TO THE INTERSECTION OF THE FLOOR LINE OF THE ASCENDING PASSAGE-WAY.

Architecturally, for the purpose of determining the height of the descending passage-way, perpendicular to its incline, this length is found to be 247.75265939+ feet. (This is a



most wonderful measure for the co-ordination of lunar with solar cycles). This measure is determined by the parallelism of the roof with the floor line of the descending passage-way. Now, to carry out another set of measures (2061.2 + 1030.6 inches), this, in practical mason work, was reduced to 247.7 feet. Col. Howard Vyse's measure was 247.71 feet (Source of Measures, p. 133).

Take the 247.7526+, to exactly determine the intersection.

### THE LENGTH OF THE FLOOR LINE OF THE FIRST ASCENDING PASSAGE, SO-CALLED.

Having arrived at the stated terminal data for closing all the lines, this distance, viz., of length of the floor line of this ascending passage-way, is geometrically found to be 1484.19608376 + *inches*, or 123.68300698 + feet. Piazzi Smyth's measure of this line is 1484.196 inches, by actual measure. His measures are as follows: Length of floor line down to portcullis blocks, 1291.2 inches; length of portcullis blocks, 178.8 inches; length thence to roof line of descending passage, 14.2 inches; total, 1484.2 inches. The author has never found any interpretation of this line. The angles of these inclines, viz., (1) of the ascending passage, and (2), of the Grand Gallery, agree to *a very few seconds* with those of Mr. Smyth. These inclines differ from each other, the angle of the Grand Gallery being the largest. The portcullis blocks are tapered, and wider at the upper end. Piazzi Smyth gives the breadth of their middle, for the average, as 38.15 *inches*. It is probably $\frac{2061.2}{54} = 38.17037+$ inches. The height perpendicular to incline may be taken as the same as that of the descending passage, viz., 47.254+ inches. Mr. Smyth gives this at these blocks as 47.3 to 47.5 inches.

NOTE.—The vertical height of the upper end of the floor of the ascending passage, above its foot, is 54.4218+ feet. Vertical height from foot of floor line of Grand Gallery to its top, 69.4825+ feet, or 833.790+ inches, then a vertical raise of 7 inches to King's Chamber level; then, by Howard Vyse, a vertical height of 831 inches to the apex of gable of roof surmounting the chamber over the King's Chamber. The vertical raise to the upper horizontal face of the great step, instead of 7 inches, is 6.2 inches. Piazzi Smyth says the polished walls of the King's Chamber extend down 5 inches below its floor surface. Vertical height of north end of great step, 30+6.2 equals 36.2 inches; length of its surface, from north end to vertical axial line, 60.726+ inches; joint of the stone is beyond this vertical axial line, so as to make the whole length of the surface of the stone 62.2 inches. From edge of great step to last cut out in floor of antechamber, or south end thereof, on one side, 229.1 ($\frac{1}{9}$ of N. cubit 2.29183, height of King's Chamber, 229.183), and from edge of great step to King's Chamber, 330.3+, by Piazzi Smyth. Width of King's Chamber, 206.2647+ inches, or 10 Nilometer cubits. Length of King's Chamber, 412.5294 inches, or 20 Nilometer cubits. Height of King's Chamber, $\frac{10}{9}$ths of 20.62647+ inches, or 229.183+ inches. Piazzi Smyth gives length of King's Chamber as 412.56 inches; breadth, 206.28 inches. He is uncertain as to the height, because of the disturbed state of the floor—become so since the time of Vyse. Vyse gives this height as 229.1. Aiton and Inglis gives this height as 229.1 to 229.2 inches. Mr. E. W. Lane gives width of King's Chamber as 206.25 inches, and length as 412.5 inches. Prof. Smyth says: N. end of great step to N. end of antechamber, east side, 113.1; west side, 113.5 inches, to S. end of antechamber, 229.4 to 229.8 inches. Whole height from floor to ceiling, from 149.2 to 149.5 inches. For Grand Gallery measures, reference is made to Prof. Smyth's works. Vertical height of foot of floor line of ascending passage above the ground level, or base of pyramid, 13.605364+ feet. Horizontal distance from same foot of floor line to vertical axial line, is the square root of 63360, or 251.714123560+ *feet.* As *inches,* 63360 inches equals 1 B. *mile,* for 63360 divided by 12 equals 5280 feet, or 1 mile. Height of north passage to antechamber, 43.7 inches; south passage, thence to King's Chamber, 43.6 to 43.8 inches. Take the forms 20612 and 2062647+ : multiply 20612 by $\frac{4}{3}$, and there results a form by which Mr. Parker procures the exact *time of the moon about the earth:* multiply this last product again by $\frac{4}{3}$, and there results a form by which he obtains the *exact time of the solar year.* Now, however, raise 20626.47+ by the same mode, *i.e.,* multiply it by $\frac{16}{9}$, add there results the exact number of inches in the total circumference of the four base sides of the pyramid.



While this work *must* appear most remarkable to any trained mind, yet, for a full appreciation of it, it is referred to experienced practical architects and engineers; those who, in addition to theoretical learning, have had great experience in the *practical application* of measures and scales of measures,